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(71) Applicant(s)
Motorola Israel Limited
(Incorporated in Israel)
3 Kremenetski Street, 678989 Tel Aviv, Israel

(72) Inventor(s)
Moshe Einat
Yaron Hasson
Gadi Shirazi

(74) Agent and/or Address for Service
Peter D Hudson
Motorola Limited, European Intellectual Property Department, Midpoint, Alencon Link, BASINGSTOKE, Hampshire, RG21 7PL, United Kingdom

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(54) Abstract Title
Inductively coupling radiation from an antenna

(57) A method for inductively coupling the electromagnetic radiation from an antenna 5 of a mobile 'phone 6, operating between 300 to 500 Mhz, involves placing the antenna alongside a helical coil (1, Figure 1) mounted on a first reflector plate (4, Figure 1) of a coupler 10. Second (2, Figure 1) and third (3, Figure 1) reflector plates are mounted normal to the first plate so as to reflect the radiated energy towards the helical coil. The coupled radiation is preferably routed to an remote antenna, e.g. one mounted on the exterior of a vehicle.

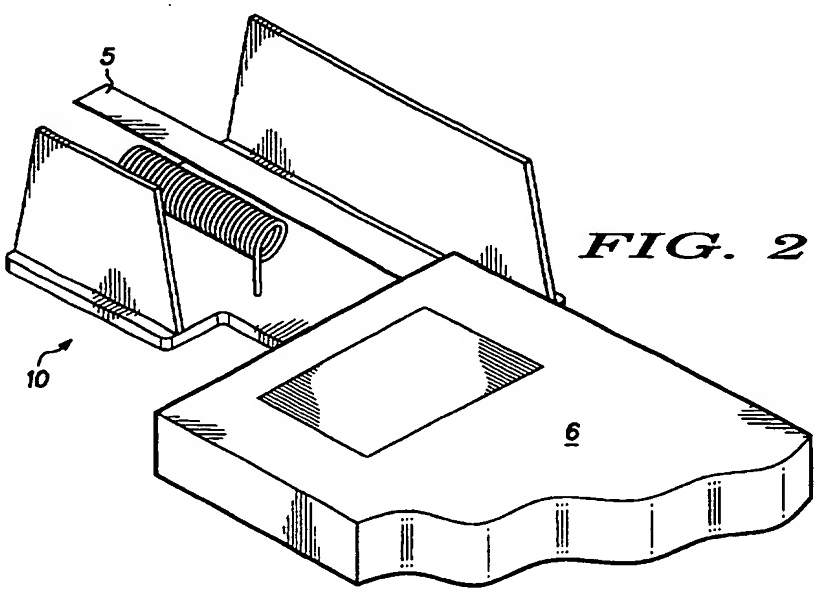

FIG. 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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METHOD AND DEVICE FOR COUPLING ELECTROMAGNETIC RADIATION

FIELD OF THE INVENTION:

The present invention is in the general field of electromagnetic energy coupling, and in particular it concerns radio antenna applications such as cellular telephones, which require coupling of Radio Frequency (RF) energy from the internal antenna of the telephone to an external device.

In many applications, it is required to couple electromagnetic energy from an internal antenna of a radio to an external device. A specific known application of electromagnetic coupling is a vehicle adapter for a cellular telephone. As is well known, receiving and transmitting RF energy through the internal antenna of a cellular telephone that is fitted in a vehicle, introduce relatively high losses of the RF signal received and transmitted by the telephone, due to the shielding of the metallic body of the vehicle.

It is therefore customary to route the RF energy to an external device (normally the vehicle's adapter), which in turn transfers the energy to an external antenna that is fitted, say, to the vehicle's roof surface. In contrast to the telephone's internal antenna that is placed in the vehicle, the external antenna can be relatively large, is fitted to an appropriate electrically ground surface and receives and transmits energy to the open space. Consequently, by using an external antenna, the RF signal quality (e.g. RF power) is substantially improved as compared to the alternative of using the internal antenna.

In order to route the RF energy to the external antenna, it must first be routed to the vehicle adapter. There are known in the literature

does not involve physical contact, the capacitance coupling solution is more reliable and brings about a longer product life span. Lastly, since the capacitance coupling device resides externally to the telephone unit (unlike the RF switch), it does not affect the unit's dimensions.

This notwithstanding, the capacitance coupling has some inherent limitations. Thus, in order to obtain better coupling, a larger plate should be employed. However, the larger the plate, the more it affects the radiating antenna operational conditions (e.g. by modifying its operating frequency) with the consequence that the overall RF coupling efficiency is reduced. A careful design would compensate between these contradicting characteristics and would bring about reasonable, albeit not ideal, energy coupling.

In some cellular telephone units, the operational oscillating frequency is 400 MHz (±100MHz) rather than 800 MHz. In the former devices, using capacitance coupling encounters serious operational difficulties. For one, owing to the lower frequency, the reactance of the capacitor (X_C) increases and the impedance follows suit. The obvious consequences are that the RF coupling efficiency also degrades. Moreover, and as is known *per se* the lower the frequency (i.e. longer wavelength), the smaller is the dimension of the capacitor that should be employed at the same distance, i.e. in this particular example a smaller plate is required.

However, and as explained above, reducing the plate size unduly degrades the capacitance coupling efficiency which in turn give rise to higher energy loss and consequently degraded RF transmission/receipt signal quality.

It is accordingly appreciated that at lower operational frequency the capacitance coupling adversely affects the efficiency of the RF coupling.

DESCRIPTION OF SPECIFIC EMBODIMENTS:

Attention is first directed to Fig. 1, illustrating schematically an inductive coupler for electromagnetic energy coupling, in accordance with one embodiment of the invention. The coupler (10) is based on geometry that includes a helix antenna (1) associated with planar reflectors.

The operation of the device will now be explained with reference also to Fig. 2. Thus, the electronic circuitry (not shown) of the cellular telephone (6) processes the voice signal of the user, converts it to electromagnetic energy and routes the energy to an internal antenna (5), all as known *per se*. The electromagnetic energy falls in the radio frequency (RF) band, and by a non-limiting example, has a center frequency of 400 MHz.

The coupler (10) is preferably fitted in a vehicle adapter (not shown), such that when the telephone is placed in the adapter's cradle, the internal antenna (5) faces the helix antenna (1). The helix antenna is *a priori* designed to substantially match the operating frequency of the antenna (1). This tuning may be accomplished using the helix antenna parameters such as antenna length, radius, the number of turns etc, all as known *per se*.

Unlike capacitance coupling where the capacitor reactance (X_C) increases (and as a result also the impedance) as the frequency drops, insofar as inductive coupling is concerned, the helix reactance (X_L) decreases (and as a result also the impedance) as the frequency drops. It is accordingly appreciated that for cellular telephones operating at 400MHz (instead of conventional devices operating at 800 MHz), inductive coupling gives rise to an improved coupling of the electromagnetic energy radiated from antenna (5) as compared to capacitance coupling.

In order to improve the efficiency of the energy coupling, a reflector element is employed. According to the specific embodiment of Fig. 1, the

tuning the operational frequency of the coupling device to, say 400MHz. Reducing the element size will, likewise, give rise to undesired energy losses.

However, unlike capacitance coupling where the plate size is the only parameter that may serve for tuning to the desired operational frequency (for a given distance from the antenna), in inductive coupler, various alternative tuning parameters , such as the number of windings in the helix antenna and the radius of the windings may be used.. In other words, the inductive coupler may be *a priori* designed to operate in the specified operational frequency using the alternative tuning parameters and maintaining the element (helix antenna) size. Accordingly, the energy losses that stem from the utilization of reduced element size are obviated.

As is well known, when a coupling element gets close to the radiating antenna, the center frequency is reduced, thereby adversely affecting the energy coupling efficiency. A possible approach of overcoming this drawback is to design the operational frequency of the coupling element to be slightly above the reference operational frequency. Thus, for the latter example, the operational frequency of the helix antenna is designed to be slightly above 420MHz, say for example 450MHz. To this end, the specified alternative tuning parameters may be used. The net effect is that the inductive coupler may be designed to the desired operational frequency without modifying the helix antenna size and thereby avoid undesired energy losses during operation.

The invention has been described with a certain degree of particularity but those versed in the art will readily appreciate that various alterations and modifications may be carried out without departing from the spirit and scope of the following claims:

8) The device according to Claim 6 or 7, wherein said radio device is a cellular telephone.

9) The device according to any one of Claims 6 to 8, further comprising:

routing means associated with said coupler, for routing said radiation to an external device.

10) The device according to Claim 8, wherein said cellular telephone operates at 400MHz±100MHz.

11) The device according to any one of Claims 6 to 10, wherein said coupler is based on a geometry that includes a helix antenna (1).

12) The device according to Claim 11, wherein said geometry further includes at least one reflector surrounding said helix antenna.

13) The device according to Claim 12, wherein said coupler is based on a geometry that includes:

a helix antenna (1) firmly mounted to a first reflector plate (4); a second reflector plate (2) mounted to one end of said first plate substantially normal thereto; a third reflector plate (3) mounted to said first plate (4) substantially opposite to said second plate (2) and normal to said first plate (4), whereby said first second and third reflector plates (4,2,3) partially surround said helix antenna (1) on three mutually orthogonal sides.

Amendments to the claims have been filed as follows

CLAIMS:

1) A coupler device for coupling eletromagnetic radiation from and or to an antenna of a radio device which coupler comprising a reflector in use surrounding at least in part the antenna.

2) The device according to Claim 1, wherein said coupler is based on a geometry that includes:

a helix antenna (1) firmly mounted to a first reflector plate (4); a second reflector plate (2) mounted to one end of said first plate substantially normal thereto; a third reflector plate (3) mounted to said first plate (4) substantially opposite to said second plate (2) and normal to said first plate (4), whereby said first second and third reflector plates (4,2,3) partially surround said helix antenna (1) on three mutually orthogonal sides.

3) The device according to claim 1 or 2 wherein said coupler is incorporated in a vehicle adapter.

4) A method or device for coupling electromagnetic radiation radiated from an antenna of a radio device substantially as hereinbefore described with reference to the accompanying drawings.